

UNDERSTANDING INSURGENCY BY USING AGENT-BASED COMPUTATIONAL EXPERIMENTATION: CASE STUDY OF INDONESIA

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ABSTRACT

Intra-state conflict is becoming an endemic feature of the post-Cold-War era, increasingly challenging international stability and security. Specifically, protracted violent conflict in the form of insurgency is being predicted as the most likely form of future warfare. This highlights the necessity of understanding the conditions under which tensions emerge within a state and converge toward violent conflict. In this paper, we use agent-based modeling as an integrative tool to understand the conditions that favor the emergence, duration, and intensity of insurgency. We present a Virtual International System developed in the Synthetic Environment for Analysis and Simulation (SEAS-VIS) to analyze insurgency in a strife-torn region of the world. SEAS-VIS provides an environment in which to conduct computational experimentation as a way to begin to understand the largely qualitative aspects of insurgency. The theoretical models used in building SEAS-VIS agents are calibrated from open-source data and validated against published real-world incidents. We then use the validated SEAS-VIS to analyze dynamic interrelationships among grievances, level of resources, and organizational capacity to mobilize members toward social action.

Keywords: Insurgency, agent-based computational experimentation, SEAS-VIS

INTRODUCTION

Low-intensity, protracted civil conflict in the guise of ethnic, religious, regional, or linguistic differences is increasingly becoming an endemic feature of the post-Cold-War era, threatening the territorial integrity and stability of various countries in the present international system. New and fast-evolving trends have contributed extensively to this growing global security threat. Globalization, especially with regard to travel and the speed of information interchange, is facilitating cooperative aggression by like-minded but far-flung individuals and groups. Messages posted on the Internet sites by radical groups to spread their ideology, mobilize for specific causes, generate funds, claim responsibilities for recent attacks, and divulge the technical know-how of weapons construction are all becoming a common phenomenon. Similarly, privatization of weapons is not only facilitating the ease of weapons acquisition but also putting the potential of macro-terrorist acts into the hands of small groups or even individuals (Victoroff 2005). According to Fearon and Laitin, the number of total dead from civil conflict (16.2 million) between 1945 and 1999 far outnumbers those from inter-state conflict

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(3.33 million). Compounding the problem is human suffering, as more and more people get displaced as a result of endemic violence and economic devastation. This necessitates the need for research communities as well as policy makers to understand the conditions under which tensions emerge within a state and converge toward violent conflict.

Insurgency is a dynamic, adaptive, and nonlinear form of low-intensity warfare. It is defined as “a technology of military conflict characterized by small, lightly armed bands practicing guerrilla warfare from rural base areas...that can be harnessed to diverse political agendas, motivations, and grievances” (Fearon and Laitin 2003). We complement this definition by adding the urban base as a chosen tactical area of operation for present-day insurgencies, since the urban terrain lends itself to anonymity, camouflage, public attention, recruiting and logistical support, and extensive media coverage. One of the key strategies of insurgency is to prolong the fight against the dominant power through asymmetric means (mobile conventional war) in order to discredit and delegitimize the government. Interrelated strategy is to maintain the precarious balance between creating dissension (through terror tactics to decrease support for the dominant power) and increasing sympathy amongst the masses for the rebel cause and/or for possible recruitment. For its production and maintenance, insurgency focuses on coordination at several levels: low-key political organization focused on recruitment and infrastructure; continuous procurement of resources for maintenance functions, such as recruiting and training; and information dissemination to generate a level of popular support. Propaganda, bombings, kidnappings, assassination, and assaults on key infrastructures are some of the known tactics that insurgents employ to create havoc and insecurity.

While conspicuous attempts are being made to synthesize explanations of insurgency, few methodological tools are available that fully integrate the theories and strategies at various levels of a socio-political system: individual, group, national, and international. This paper uses Synthetic Environment for Analysis and Simulation-Virtual International System (SEAS-VIS) (Chaturvedi et al. 2004), an agent-based system, to study insurgency in Indonesia. In recent years significant research has emerged using agent-based modeling as a technique to elucidate the causes of protracted civil conflicts. Notable studies are on ethnic mobilization (Bhavani and Backer 2000; Srblijinovic et al. 2003; Cederman 2005), emergence of ethnocentrism (Axelrod and Hammond 2003), and emergence of secessionism (Lustick 2004), to name a few.

One of the advantages of using agent-based modeling is that it overcomes some of the difficulties associated with the real world. One of the difficulties pertains to the scarcity of comparable and generalizable cases of insurgency, which, in turn, are context- and time-dependent. Second, the enormity of variables and interaction effects and the immense difficulty in gathering relevant data pose daunting challenges to scholars and policy makers and can, at best, lead to only a partial understanding of insurgency and of its mitigation. Finally, real-life cases are serious risks to the local implementers, who often lack the necessary information or the optimal solutions for conflict resolution (Lustick et al. 2004).

Computational experimentation methodology presents an innovative way of analyzing protracted conflicts. In this approach, one re-creates the environment on the basis of theoretical models of behaviors and calibrates them to fit the situation at hand. If the theoretical models are robust enough, then the situations when re-created can give revealing insights into the situations under investigation. Obviously, there will always be a lack of data and deep understanding of the flow of information, the interaction between the key actors, and the cascading effects of events leading up to the conflict. An agent-based synthetic environment allows us to fill in the gaps

through experimentation with the solitary and collective behaviors of individuals, groups, organizations, and institutions. Specifically, agent-based modeling can have immense usage in the social sciences that are still concerned with how macro-level phenomena emerge from micro-level actions. According to Sawyer, the “emergence of macro from micro is perhaps the most interesting feature of artificial societies. In the artificial societies...macro-structural phenomena emerge, attain equilibrium, and remain stable over time. Thus, artificial societies provide sociologists with a tool to explore the micro-to-macro transition” (Sawyer 2003, page 333). As Cederman (2004, page 6) aptly portrays:

“agent-based models constitute artificial and indeed simplified worlds in which the plausibility and consistency of well-specified causal mechanism can be evaluated in a context that is more complex than that of standard, rationalistic modeling tools, but still much simpler than the real world. Serving as a stepping stone between micro and macro analysis, such models can help untangle interacting mechanisms that together generate the phenomenon to be explained. This perspective defines a generative research strategy that starts from such patterns and moves backward in the search for candidate mechanisms that could generate observed outcomes.”

Further, this new tool allows us to integrate and evaluate various existing theories, paradigms, and courses of actions in a single holistic framework. This “third way of doing science,” as eloquently stated by Axelrod (2003), is a “virtual” interactive system that creates artificial autonomous agents that mimic the behavior patterns of their counterpart in the real world. These autonomous agents “have control over their own behavior and can act without the intervention of humans or other systems” (Sawyer 2003). They can interact with other agents within the virtual environment and are able to communicate, negotiate, and cooperate with each other. Agent-based simulations allow the following (Buodriga and Obaidat 2004; Chaturvedi et al. 2005; Sawyer 2003):

- Virtual experimentation, in which consequences of decisions can be measured and analyzed;
- Integration of multiple theories from various specialized disciplines, for a comprehensive understanding of underlying phenomena;
- Creation of representation of agents with multiple decision strategies, both rational and nonrational;
- Modeling of heterogeneous actors who can modify their behavior during the course of the simulation; and
- Facilitation of a seamless and interchangeable integration of human and software agents.

In the following sections, we begin by briefly describing some of the key theoretical premises that elucidate conditions favoring insurgency — premises that we use for the model development and computational experimentation. This is followed by a description of SEAS-VIS. We then present the configuration of a small-scale artificial society within the VIS

concept to study the impact of external shocks (tsunami) and the critical role of organizational mobilization on the level of insurgency.

DETERMINANTS OF REBELLION: MOTIVE, RESOURCES, AND ORGANIZATION

Research on conditions favoring rebellion is rich and varied. Theories explicating rebellion are a combination of economic, political, symbolic, and psychological factors essential to the development of conflict. We draw upon three well-established concepts — grievance, resources, and mobilization — as explanations of protracted rebellion.

Deprivation Theory

One of the dominant perspectives in the study of intra-state conflict is the deprivation model, which examines the range of discriminations and disparities experienced by minority groups as contributing factors of rebellion. Deprivation can be in the form of psychological (perceived inequality), economic (resource inequality), political (repression, lack of political rights or representation), or social inequity (inequality such as group domination and suppression) (Gurr 1970, 2000; Schmid 1983; Harmon 2000; Krueger and Maleckova 2002; Duckitt et al. 2002; Post et al. 2003; Besancon 2005). Two underlying assumptions characterize this concept. First, rebellion may be due to an increase in the gap between expectation and outcome (i.e., a gap between the valued things and opportunities that people think that they are entitled to and the things and the opportunities they actually get). Second, there is continuous and crucial comparison with other people or groups. It is the sense that one's group is not doing as well as other groups. Thus, deprivation is a "psychological process in which judgment is made relative to one's own expectations. The aggregation of these individual perceptions and frustrations leads to a social movement intent on violent political change" (Regan and Norton 2005).

Rebel-Resources Theory

A more recent body of research analyzes extensively the connection between natural resources and likelihood of conflict (Collier and Hoeffler 2004; Fearon 2004; Weinstein 2005; Regan and Norton 2005; Humphreys 2005; Lujala et al. 2005). In an influential paper, Collier and Hoeffler (2004) suggest that states that depended extensively on natural resources for capital generations were more prone to civil violence. Natural resources (especially lootable resources) can provide finances to rebel groups and increase the prospects of their success and decrease prospects for peace, since continued conflict may be more profitable for the rebels than an outbreak of peace (Addison et al. 2002; Ross 2004). Notable cases are in Sierra Leone, Congo, and Angola, where rebels used revenues from diamonds and other natural riches to finance their conflict against the government. When natural resources are concentrated in one area of the country, insurgent groups may be motivated by the assumption that seceding may be prosperous. Resources are also used as selective incentives to overcome the uphill battle of convincing and motivating individuals to rebel (Weinstein 2005).

One of the corollaries to the natural resource hypotheses is the existence of weak and natural-resource-dependent economies as being more violence-prone and a fertile and conducive

environment for the development of insurgencies (Fearon and Laitin 2003; Collier and Hoeffler 2004). Especially in developing economies, the legitimacy of the government is much weaker as regimes are narrowly based, come to power by force, and remain in power by suppression. Maintaining power for these regimes also requires effective control over natural resources, since they remain vulnerable to many different groups who would like to gain control of the state through that very means. Regimes, as well as subnational groups, may also advance their interest by seeking outside support that is often granted, since abundant natural resources within a country may be an incentive for third parties, such as states or corporations, to engage in or foster civil conflict. A classic case in point is the competition between the United States and France over oil in Chad and their subsequent interference in Chadian politics that has “made and broken political leaders, has incited violence, and has shaped political agendas” (Humphreys 2005). There is extensive research on the international linkages that provide groups with popular encouragement through information warfare or resources, such as weapons, money, and training, as necessary to prolonging insurgency (Byman et al. 2001; Lobell and Mauceri 2004). Where the central authority has weakened or collapsed, predatory outside groups can take advantage of this situation in order to capture the spoils. Ethno-religious groups with affinities in neighboring states or otherwise can solicit support, resulting in diffusion of crisis.

Organizational Mobilization Theory

A contending perspective argues that organizations are the core protagonists of action and activism as a result of the mobilizational capacity of groups and organizations. Thus, deprivation is a necessary but not a sufficient explanation for rebellion (Tilly 1978; Tarrow 1994; Lichbach 1998). For example, advocates of resource mobilization theory focus on what compels aggrieved people to participate in social movements. They contend that organizations possess certain materials and resources that they use to generate actions that lone individuals are rarely capable of. These resources are generated by continuously participating in “supply chain” activities, such as resource procurement, accumulation, and recruitment of new members in order to sustain themselves. These resources, in turn, are directed toward activities that meet organizational goals. Organizations also provide their members with a sense of identity, existence, boundedness, coherence, agency, and mission that together may propel individuals toward violent behavior and provide justification for the same (McCarthy and Zald 1976; Tilly 1978; Jenkins 1983; Tarrow 1994; Klandermans 1984; Lichbach 1998; Brubaker 2004).

SEAS-VIS MODEL DESCRIPTION

We create a multi-level artificial society within the SEAS agent-based computational experimentation environment to test the three intra-state strife theories. We implement diverse social science theories in two distinct ways. (1) Certain fundamental or experimentally developed theories are explicitly encoded in the agents. Examples included well-being (Diener et al. 1993; Diener and Fujita 1995; Diener and Suh 1998; Diener and Lucas 1999; Peterson 1999; Diener et al. 1999; Kahneman et al. 1999), set point theories from psychology (Suh et al. 1996; Lucas et al. 2003; Lyubomirsky et al. 2005), and production and consumption theories from micro economics, etc. (2) Certain theories that represent emergent behaviors are observed and validated on the basis of the calibration of the primitives. Examples of such theories include sociological theories, such as social networks, and macro-economic theories, such as gross national product (GNP) and unemployment.

We configure Indonesia, a multi-ethnic virtual state within the SEAS-VIS, mirroring its counterpart in the real world. Virtual Indonesia is represented by four primitive constructs: individuals, organizations, institutions, and infrastructures (IOII). These four primitives are used to model higher-order constructs, such as geographical entities (nations, provinces, cities), political systems (type of government, political parties/factions), the military (soldiers, institutions), economic system (formal and informal structures), social systems (institutions, groups), information systems (print, broadcast, internet), and critical infrastructures (banking, oil and gas, electricity, telecommunications, transportation), as shown in Figure 1.

Political and social systems of a state are modeled as a multi-agent system representing the human elements. Individual citizen agents are constructed as a proportional representation of the societal makeup of a real nation. Each individual agent consists of a set of fundamental constructs: traits, well-being, sensors, goals, and actions. For example, a citizen agent is encoded with static traits (e.g., race, ethnicity, income, education, religion, gender, and nationalism) and dynamic traits (e.g., religious, political, societal, and violence orientations). We use Kahneman's (1999) concepts of subjective well-being, which refers to a person's assessment of his perceived state of happiness or well-being. The agent's well-being consists of eight needs: basic, political, financial, security, religious, educational, health, and freedom of movement. Traits and well-being together determine the set of basic goals for a class of agents. An agent uses its "sensors" to sense the environment and listen to messages from his/her leader(s), the media, and other members of the society. On the basis of the sensed information, each agent can autonomously choose from its repertoire of configurable action sets or adjust its goals. Traits, well-being, and goals determine the available actions each agent can take. For example, an agent can migrate to a different location (geography) to seek a better job to satisfy its financial well-being. Traits, well-being, sensors, and actions together determine the behavior of the agent.

We identify each agent's *desire* for each need. These desires are initially populated for each citizen on the basis of the socioeconomic class of the citizen. Further, we also identify

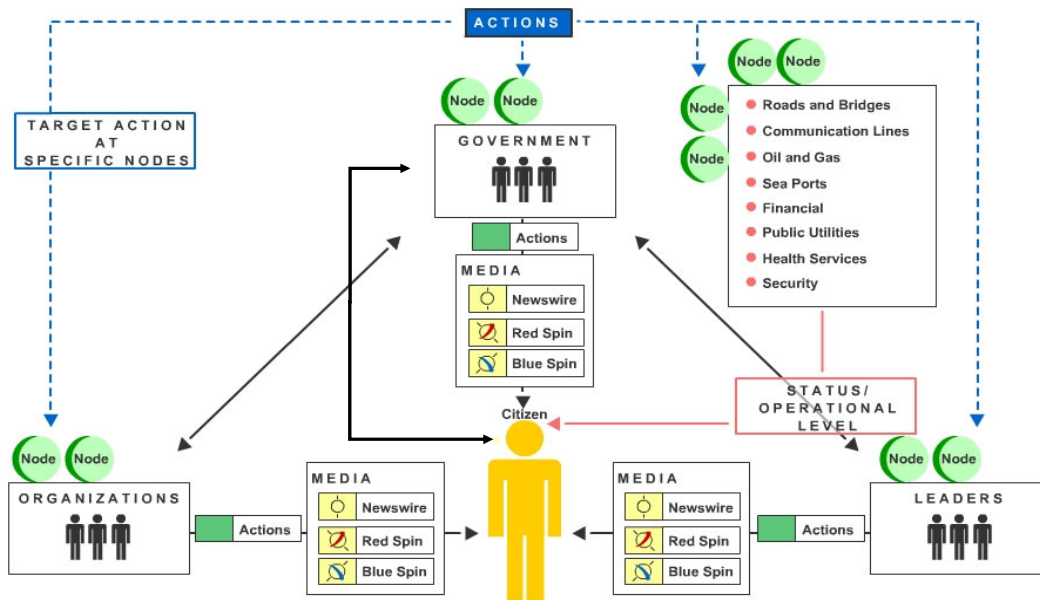


FIGURE 1 Schematic of SEAS-VIS

weights that identify the relative importance of the fulfillment of each need to the citizen. Each citizen forms a perception of the level of fulfillment of each need from several information sources, such as social groups, leaders, organizations, and the media. Each agent then identifies the deprivation of each need as the gap between the perception of a need and his/her desires for the need. By weighting the deprivation of each need, each citizen identifies the overall deprivation.

Over long periods of time, citizens adjust their desires for each need relative to their perception of that need. A citizen could be influenced to adjust desires by organizations and leaders through coercion or persuasion. Each citizen's desires are also influenced by the desires of other citizens in his social network. The increase in perception of needs of a few citizens could lead to higher desires not only in those citizens but also other individuals in their social groups. Such an adjustment of desires across social groups whose perceptions do not change could lead to a higher sense of deprivation in the citizens of the social groups.

Citizens adjust their *weights* as certain needs become more significant because of conditions in the environment. Citizens focus on needs that they are most deprived of and attach less significance to those needs that are fulfilled. Organizations, leaders, and the media could influence a citizen into adjusting weights by attaching significance to certain issues. Citizens are also influenced or coerced by their social groups in the needs to which they attach the most significance.

The leader agent is encoded with influence levels that reflect his/her power within the group, organization, or institution. A leader agent is categorized as social, religious, and/or political and has a repertoire that is larger than that of citizen agents and includes additional traits, such as power base, ideology, and his/her stance on economic, political, and social policies. Leader agents are able to affect the political and social climate of the synthetic environment and impose their stances upon citizens and organizations to promote their respective goals. The goal of leader agents is to set the agenda of the organization or institution in which they reside and persuade the citizen/member agents to make decisions that favor those positions.

Clusters of agents form groups, organizations, or institutions. They differ from individuals with regard to the rules that govern their behavior and intent. Groups are either informal or formal. Formal groups' rules of engagement are published and are relatively static, while those of informal groups are only known to their members and continuously evolve on the basis of interactions among the environment, leader, and members.

An organization is composed of a structured group of artificial human citizen and leader agents. Citizens that subscribe to an organization make up the member population, and the combined behaviors and interactions of members and leaders results in the behavior for the organization. Organizational leadership constantly seeks maintenance and growth of the organizational membership by providing tangible and intangible benefits, and citizens subscribe on the basis of a perceived level of benefit that is received from the organization. Leaders attempt to influence the organization to align with their ideologies by framing issues and attitude sharing. Members also influence each other's attitudes through the formation of intra-group social networks that emerge from levels of affinity between members. In addition, through inter-organization networks, attitudes and resources may be shared between organizations. Through these internal and external interactions, organizations cause significant changes in

perception and attitude change and become core protagonists of activism in the model. The interaction between organizations and other entities is shown in Figure 2.

Organizational deprivation is modeled in terms of the well-being and attitudes of leaders and members. As well-being decreases and attitudes become more hostile, an organization may choose to mobilize to action in the form of a demonstration, a riot, or an attack. The course of action depends upon the ideology of the organization and the extremity of the unrest. An organization that is more willing to use violence to achieve its means may be more prone toward rioting or suicide-bombing attacks, whereas an organization that subscribes to nonviolent means may choose to arrange a demonstration.

An organization exercises its power through the control over its resources and its ability to procure and maintain its resource base. Organizational networks, member recruitment, and member maintenance are primary sources of resource procurement and maintenance. A higher level of control over these resources contributes to a higher level of effectiveness when organizations are mobilized to action.

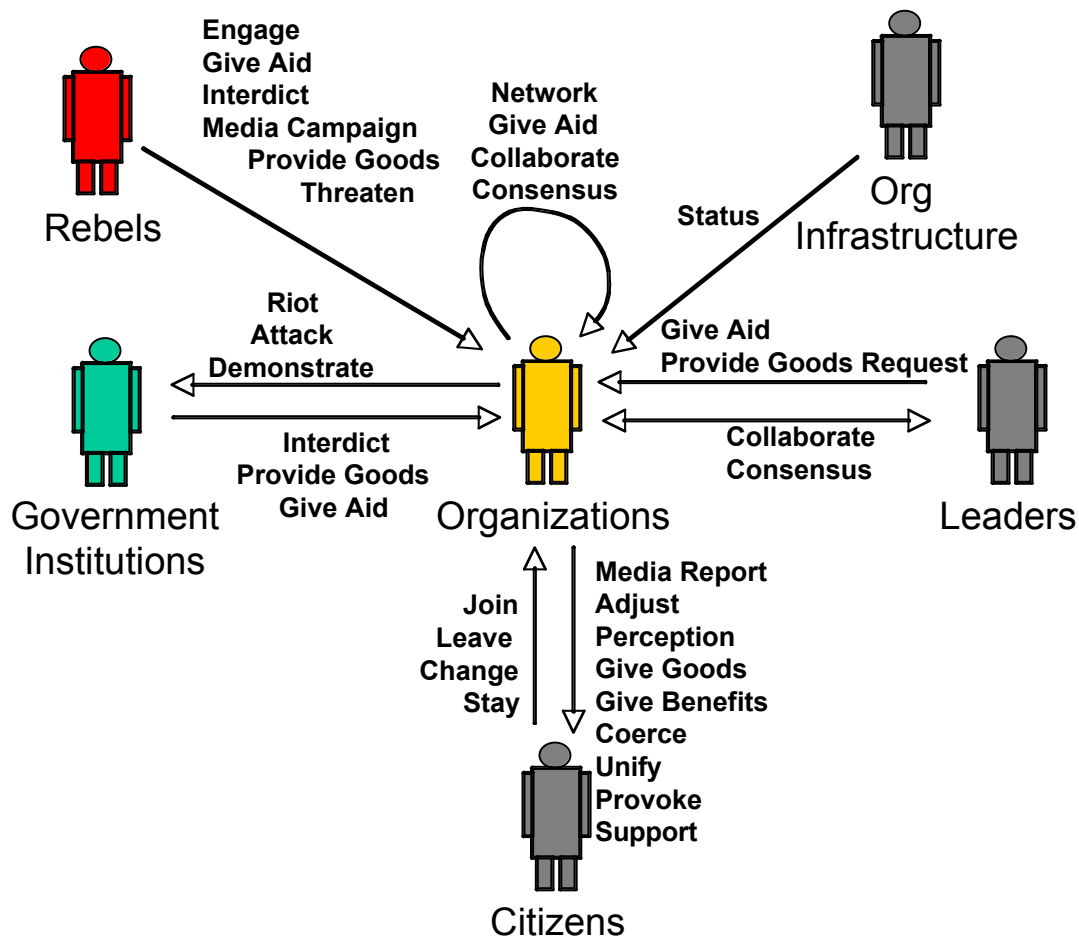


FIGURE 2 Interactions between organizations and other entities

Agenda setting is a significant contributor to organizational activism in the model. Every organization sets an agenda based on its ideology and goals that directs mobilization. This agenda is adaptive and dynamic as a result of intra-organizational and inter-organizational information sharing. Internally, leaders influence the attitudes and perceptions of well-being of their members and other leaders, and members share like information within their own social networks. Externally, organizational networks impact perceptions and attitudes through the interactions among leaders as well as member social networks across organizations.

Within our model, the media also play a significant role in providing information to members in the form of reports on well-being and attitudes. Media organizations consist of television, radio, newspapers, and magazines. They make choices about what information to cover, which people to cover, what statements to report, what story elements to emphasize, and how to report the information. The media is able to set the agenda for domestic policies as well as foreign policy issues. Incidents are framed on well-being components and formalized in a media report. For example, if the media's agenda is to arouse public against the government and if basic needs are below a certain threshold level, then the media frames it as government being responsible for the dire conditions of the people. Citizens subscribe to a media organization on the basis of their ideological bent. Subscription to a particular media is dependent upon the congruence of the ideology of the media with the ideology of the citizens subscribing to it. Media organizations are primarily focused toward framing the issues for their audiences in such a way that they increase their viewership as well as their influence. When the media infrastructure agents are reduced in their capacity to report, then the media conglomerates are also decreased in their ability to spin reports.

We model institutions as “governmental entities,” such as the army, police, legislature, courts, executive, bureaucracy, and political parties — entities that are able to formulate policies that are legally binding and that have more discretionary resources. We also consider institutions as structures that are products of individual choices or preferences, the later, in turn, being constrained by the institutional structures (i.e., an interactive process). The government institution agents represent the leadership and various branches of the government. Institutions are like formal organizations with an additional power to influence the behaviors of members and nonmembers.

Examples of traits, well-being, sensors, and actions of different classes of agents are given in Table 1.

INSURGENCY INDICATOR

Epstein (2002) and Cederman (2004) have modeled civil violence wherein a central authority seeks to suppress unorganized rebellion. By building upon these models, and using the three well-established concepts of grievances, control over resource, and mobilization, we define a metric called *Insurgency Indicator* to indicate the overall level of insurgency against the government in a region. At the aggregate level, *Insurgency Indicator* is observed as the ratio of the number of mobilized citizens to the total population. It is given as:

$$\text{Insurgency Indicator, } S = \text{total number of mobilized citizens} / \text{total population.}$$

TABLE 1 Traits, goals, sensors, and actions for each entity type

IOI Categorization	Entity Type	Traits	Goals	Sensors	Actions
Individual	Citizens	Age Income Education Ethnicity Religion Ideology	Maintain and enhance personal well-being	Leaders Organizations/media Institutions	Demonstrate Riot Join organizations Leave organizations
	Leaders	Type Power oriented vs. affiliation oriented Responsive vs. ideologue Ethnicity Race Income Education Attitude towards group, state	Maintain and enhance personal influence Maintain and enhance the influence of their organization Maintain and enhance well-being of their members	Followers' well-being Organizational power base Control over resources	External Consensus Collaborate Internal Set agenda Unify Coerce
Organization	Informal groups Formal organizations Networks	Type Political, religious, social, economic, media Size Control over resources Ideology Ethnicity Nationalism Religion	Survive Maintain Increase membership Seek influence	Member well-being Other organizations	Demonstrations Riots Attacks Set agenda Collaborate Unify Seek consensus Coerce
	Government	Type Political Military Economic Spatial Central Provincial Local Power Resource Competence Nationalism	Policy implementation Policy adjudication Policy enforcement Policy formulation Influence policies	Population's well- being component Public's confidence/ legitimacy Public's trust Resource availability Other institution's actions Incoming actions DIME actions	Collaborate Unify Coerce Enforce Respond Prepare Recover Reconstruct Attack Ally Defend Aid Coerce Trade

Each individual agent evaluates its position at multiple levels in order to determine its intention to mobilize and join the rebellion. This intention of a citizen agent to rebel depends upon its grievance and its perceived net risk in acting against the grievance.

Each agent evaluates its personal grievance against its government. This is measured as a function of the agent's subjective well-being and its perception of its government's legitimacy. Therefore, high deprivation may be either counterbalanced by a high legitimacy or bolstered by a low one in producing a grievance against the government. It follows from the previous description of deprivation and organization models that the grievance of a citizen therefore

depends on his or her base desires, perceived reality through media reports, and the actions/attitudes of organizations, leaders, and the government.

An agent's net risk in addressing its political grievance is the product of its level of risk aversion and perceived incarceration or punishment. The risk propensity of an agent reflects diminishing returns to increasing gains and losses as held by prospect theory, so that agents decreasingly become risk acceptant when faced with increasing erosion in well-being. The perceived probability of incarceration increases with repression and enforcement, while it decreases with the number of citizens already mobilized against the government.

Therefore, a citizen's intention to join the insurgency is determined as follows:

Intention to Rebel, $I = f \{grievance, risk propensity\}$,

Grievance, $G = f \{subjective well-being, legitimacy\}$,

Subjective Well-being, $W = f \{basic needs, political needs, financial needs, security needs, religious needs, educational needs, health needs, and freedom of movement needs\}$,

Legitimacy, $L = f \{government actions; media, organization, and leader attitudes\}$, and

Risk Propensity, $R = f \{media, organization, and leader actions\}$.

ILLUSTRATIVE SCENARIO: INSURGENCY IN ACEH, INDONESIA

We create Virtual Indonesia (VI) within SEAS-VIS. VI consists of political, military, social, economic, information, and infrastructure entities or nodes. The behaviors of these nodes were mined from open source data (Polity IV, Indonesia Public Opinion Survey 2005, CIA Fact Book, Wordpress.org, *Europa Magazine*, etc.). We model behaviors of a total of 474,073 agents. Included in this count are 473,500 citizen agents, 9 named leaders, 9 named organizations, 9 media organizations, 14 sectors, and 406 critical infrastructure nodes. The interactions between these nodes are emergent. Individuals, organizations, and institutions modeled in VI are given in Table 2.

Our experimental setting consists of the six phases outlined below. In these phases, we observe how the insurgency indicator fluctuates over time during the period December 2004 and August 2005 and use that as a basis for prediction until February 2006. We explain the reasons behind these fluctuations based on citizen agents' well-being and the roles of the media and organizations in mobilizing them to rebel against the government.

- A. Pre-tsunami: We calibrate our experimental scenario for Aceh, Indonesia, where there is a pre-existing active secessionist movement led by GAM and its leader Hasan Di Tiro. We insert Tsunami as an external shock to the system at the end of this phase.

TABLE 2 Named agents and agent classes

Citizen (473,500)	Named Leaders (9)	Named Organizations (9)	Media (9)	Sectors (14)
Javanese	Yusuf Kalla (VP)	Golkar	Jakarta Post	Oil
Acehnese	Megawati	PDI P	Indonesia Times	Gas
Sundanese	Sukarnoputri	PPP	Jakarta Times	Power
Batak	Hamzah Haz	GAM	Jaringan Islam	Education
Minangkabau	Husan di Tiro	NU	Liberal	Financial services
Banjarese	Hashim Mujadi	Muhamadiya	Sinar Harapan	Agriculture
Bantanese	Amien Rais	Jemmah Islamiyah	Voice of Islam	Water
Madurese	Abu Bakar Bashyir	MMI	Radio Republik	Manufacturing
Buginese	(Leader of MMI)	Democrat Party	Indonesia	Military industrial
Betawi	Susilo Yudhoyono (P)		Televisi Republik	Transportation
Chinese			Indonesia	Telecommunication
Malay				Government services
Other				Labor
				Capital

- B. Immediate aftermath of tsunami: We insert our best approximation of response to the calamity by the local government and the international community.
- C. Post-tsunami recovery.
- D. Intermediate aftermath of tsunami.
- E. Local government permits greater freedom to citizen and media while interdicting organizations.
- F. Prediction of the outcome of government policies on insurgency indicator.

Figure 3 shows the insurgency indicator for Indonesia and three specific provinces, while Figures 4 and 5 illustrate the impacts of deprivation, changes in resource levels (flow of aid), the media, and organization mobilization on the indicator. Using these results, we discuss here the fluctuations of insurgency in Aceh.

Insurgency in Aceh rises sharply in phase B. This spike is explained by the acute deprivation following the Tsunami and increased political grievance resulting from the delay in relief from the government. As media attitude is mostly pro-rebel and anti-government, citizens perceive the government relief effort to be ineffective in meeting their needs and blame it for their hardship. Hence, citizens are mobilized by hostile organizations like GAM.

In phases C and D, flow of international aid leads to reduction in deprivation and a positive shift in media attitude (anti-government, centrist, and moderate right media conglomerates). Furthermore, opposition groups and leaders, such as PDI-P, GAM, Golkar,

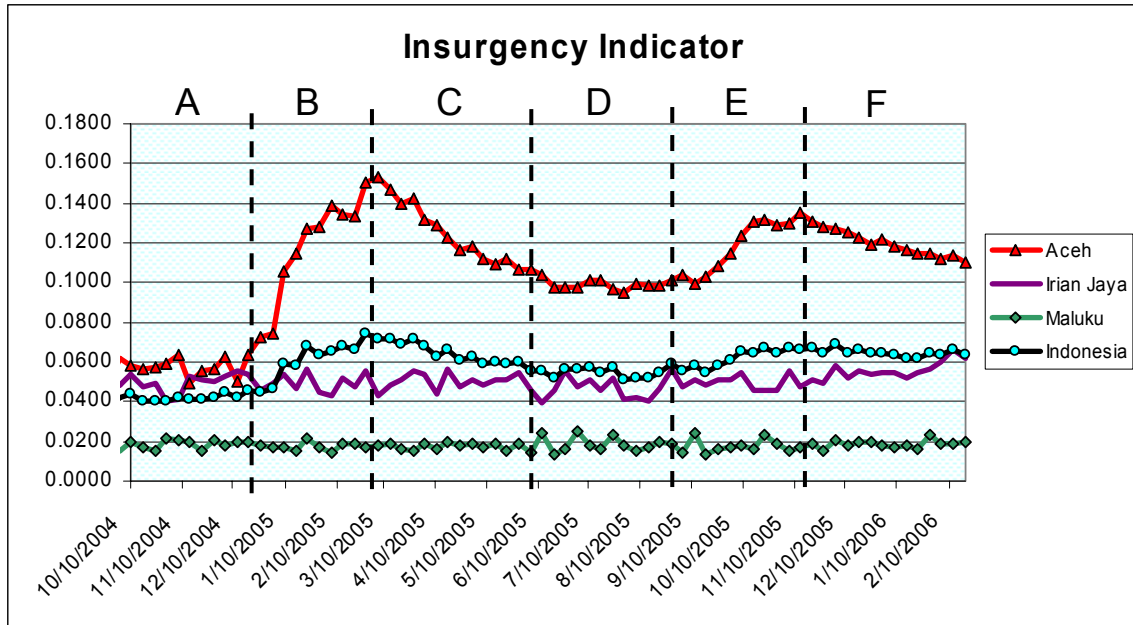


FIGURE 3 Insurgency indicator over time

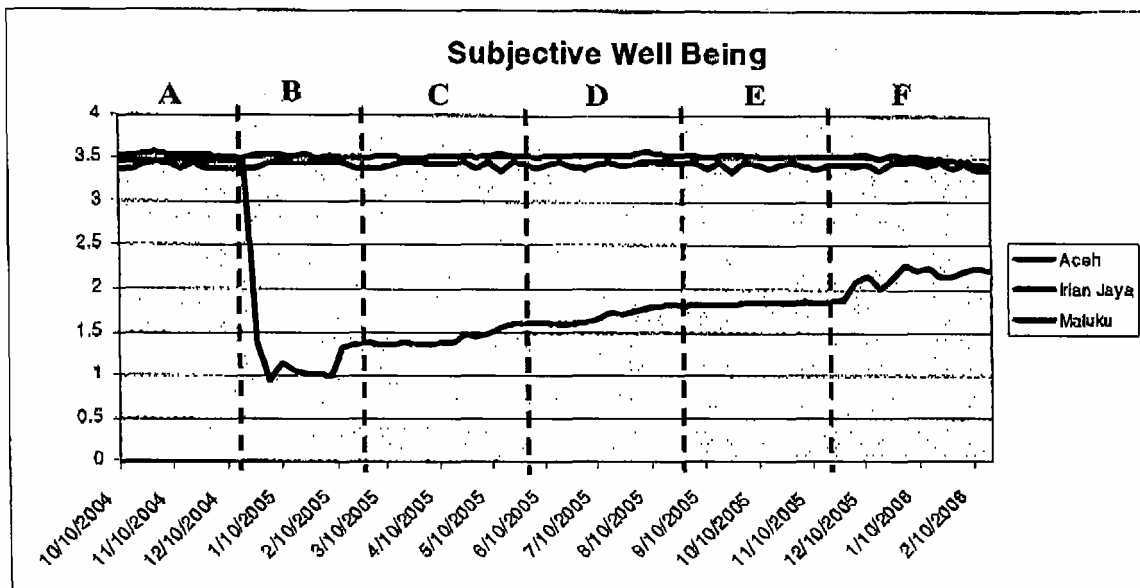


FIGURE 4 Impact of deprivation and grievance on well-being

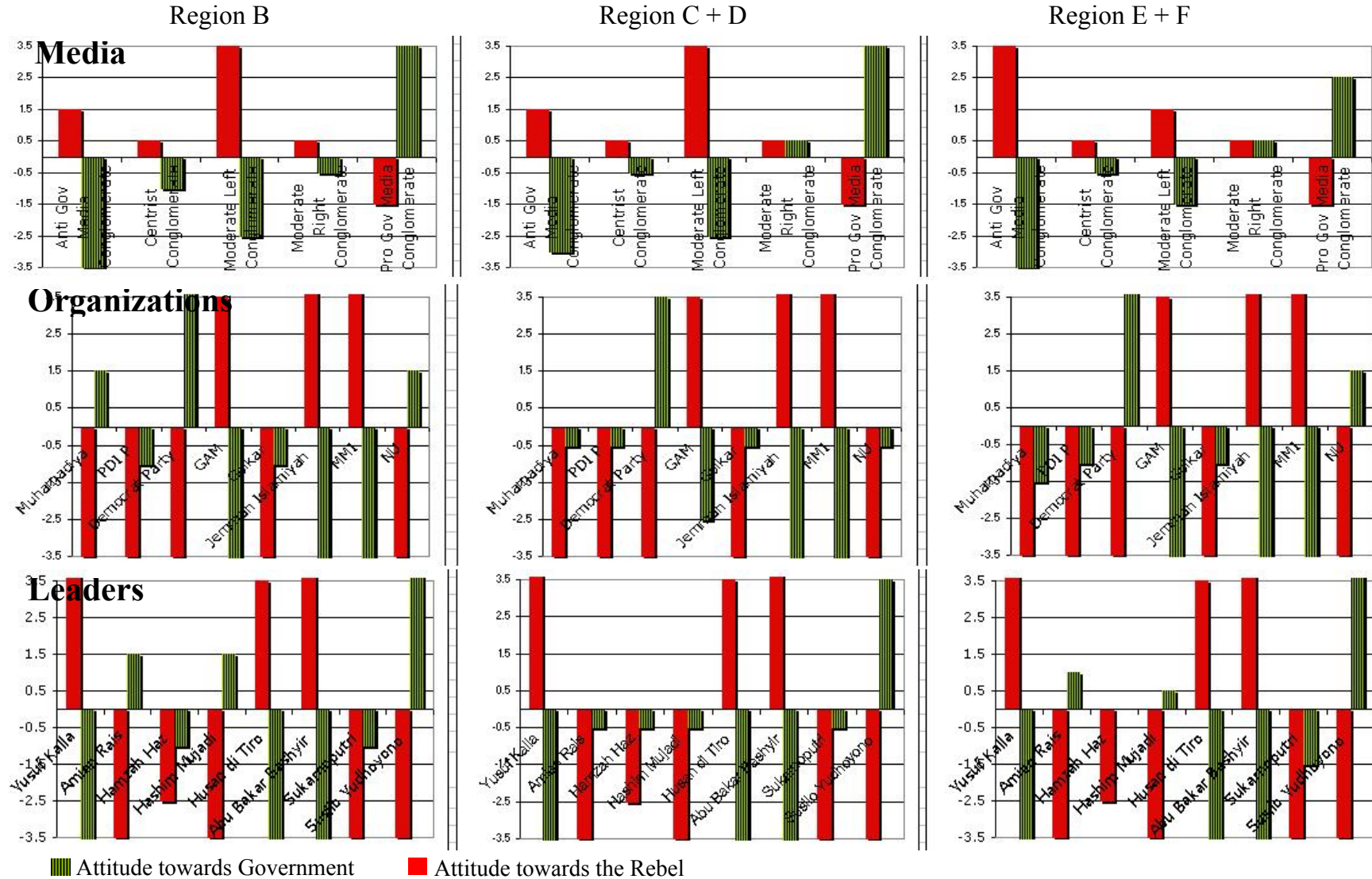


FIGURE 5 Role of media, organizations, and leaders in shaping citizen attitude and behavior, thereby determining the insurgency level

Hamzah Haz, and Sukarnoputri, soften their anti-government attitudes as they become more willing to cooperate. As a result, fewer citizens get mobilized, and insurgency is gradually mitigated.

In the predictive phase, with a government policy change, insurgency spikes initially (phase E) due to risk-acceptant citizens, media that is now free to favor the rebels (anti-government and pro-government media conglomerates), and organizations that respond negatively to being indicted (Muhammadiyah, PDI-P, GAM, and Golkar). However, insurgency gets slightly alleviated in region F, primarily as a result of the continued aid and citizen freedom that increase aggregate well-being. In addition, the government has more support from leaders like Amien Rais, Hamzah Haz, and Hashim Muzadi, along with the organization NU.

CONCLUSION

In this paper, we present an agent-based simulation of intra-state conflict to understand the conditions that favor the emergence, duration, and intensity of insurgency. We present a Virtual International System developed in the Synthetic Environment for Analysis and Simulation (SEAS-VIS) to analyze insurgency in a strife-torn region of the world. SEAS-VIS provides an environment in which to conduct computational experimentation as a way to begin to understand the largely qualitative aspects of insurgency. We use theoretical models to configure SEAS-VIS agents, calibrate them from open-source data, and validate them against published real-world incidents. We model a total of 474,073 agents, with 473,500 citizen agents, 9 named leaders, 9 named organizations, 9 media organizations, 14 sectors, and 406 critical infrastructure nodes. We then use the validated SEAS-VIS computational experimentation environment to analyze dynamic interrelationships among grievances, level of resources, and organizational capacity to mobilize members toward social actions.

ACKNOWLEDGMENTS

This research is partially funded by grants from the National Science Foundation, Indiana State 21st Century Research and Technology Fund, and the U.S. Department of Defense.

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